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The Effectiveness of Biochar in Composting of Food Waste

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Abstract: Biocompost is an organic matter that has been decomposed under a controlled aerobic condition to produce materials that used for an agriculture sector. It is used either as a fertilizer or soil amendment. Compare to chemical fertilizer, biocompost have advantages in term of releasing nutrients, improving the structure of the soil, the ability to hold water and nutrients, the risk of toxic build-ups and environmentally friendly. The objectives of this study were to determine the temperature profile of composting with the addition of biochar and without biochar and also to determine the oxygen content and the ratio of carbon and nitrogen. Composting experiment was conducted by mixing food waste and biochar with the ratio of 3:1 with a total weight of approximately 4 kg. Samples from compost bioreactor were taken within the period of time namely day 5th, 10th, 15th and 20th. This study had been revealed that the addition of biochar for composting will rapidly increase the temperature to achieve the thermophilic phase at the maximum temperature was approximately 56.0°C within 5 days. C/N ratio and oxygen also increase with the range 30.85-42.07 and 37.78-52.28%, respectively. Hence, biochar can be one of the most effective additives to optimize the production of biocompost.

Key words: Biochar, food waste, biocompost, toxic, aerobic, optimize

INTRODUCTION

Food waste is considered as a major waste produced from a daily basis of different sectors and activities and can be divided into three different groups namely loss of food, inedible food waste and edible food waste (Thi *et al*., 2015). Food waste is categorized under the disposal of solid waste which under the Malaysia Solid Waste and Public Cleansing Management Act 2007 (Act 672), the disposal method may be from destruction, incineration deposit or decomposing (Nagapan *et al*., 2012). The composting process produced from food waste is considered as an alternative way to overcome the problem related to food waste. In composting which is an environmentally friendly biochemical way and a sustainable food waste management (Jara-Samaniego *et al*., 2017). After anaerobic digestion, composting has a good impact value to the environment as well as economic than other waste management like incineration studies proved by Life Cycle Assessment (LCA) (Korres and Nizami, 2013). Naturally, in the composting process, a lot of microorganisms break down the intricate organic matters into simpler products and finally into a valuable compost. Usually, the composting process takes about 4-8 months but using accelerating techniques such as turning frequently and feedstock shredding using microorganism (Sun *et al*., 2016), chemical nitrogen activators, worms and natural minerals and various additives and amendments (Chan *et al*., 2016) can greatly reduce the duration of the processing period. Using additives such as biochar to enhance the composting process is getting more popular in recent years due to its unique physiochemical characteristics (Czekala *et al*., 2016). Biochar is rich in carbon material which is produced through pyrolysis of biomass (Dias *et al*., 2010). The biochar's physiochemical characteristics depend on the feedstock composition and pyrolysis temperature (Jindo *et al*., 2016). In the process of composting, biochar is used as a bulking agent and plays an important role in providing the aerobic conditions to compost materials (Zhang *et al*., 2014; Bass *et al*., 2016). In a similar way, during the process, the functional group of the biochar adsorbs various essential cations and anions produced in the compost (Bass *et al*., 2016). Additionally, the microporous structure absorbs a common solvent such as moisture (Wei *et al*., 2014). However, the mechanism of degradation and mineralization of organic waste in the presence of biochar is rarely reported in the scientific literature (Bass *et al*., 2016) which is the focus of this study.

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MATERIALS AND METHODS

Feedstock preparation: Food waste was collected from the cafe of Block M of Universiti Teknologi MARA (UiTM), Kota Samarahan, Sarawak with total about 7.0-5.0 kg and the Biochar was collected at Satoyama Farm Sdn. Bhd. Non-compostable in a food waste such as rubber band, plastic, wooden stick and chicken bones were removed. Then, food waste was dried under air drying within 1 h in order to achieve the desired moisture content for composting process which is <70% as per standard guidelines of Brinton (2000) and EPA (2014). For laboratory analysis, food waste particle size was reduced into a small particle approximately 5.0 cm by cut it manually with scissor. Biochar was crushed into a powder form by using a mortar and filtered. Food waste and biochar were well mixed in the beaker with a ratio of 3:1 (3 kg of food waste mixed with 1 kg of biochar) which approximately totals 4 kg of mixed compost.

Experimental scheme: The mixed compost was placed onto mixing chamber inside the composter reactor and then it spread out evenly within the composter reactor to ensure aeration of the compost as explained by Jindo *et al*. (2016) and this allows smooth turning of the mix bar. The duration of this composting analysis was 20 days. Sample collection for compost experiments was carried out after every 5 days throughout the experiment till day 20. The 15-20 g of sample was taken from composter reactor and analyzed for ultimate value namely carbon, hydrogen, nitrogen and oxygen. The temperature also was recorded for every 5 days.

RESULTS AND DISCUSSION

Temperature of biocompost: Figure 1 shows the temperature profiles of biocompost with and without biochar with variation day. At day 1st the temperature of biocompost with biochar is approximately about 39.09°C is slightly higher compare than biocompost without biochar at 31.50°C. This level of temperature is catered for the mesophilic phase or early stage of decomposition of bio-compost by the microorganism. Recent research findings are revealed that addition of biochar to composting mixture rapidly increased the temperature to thermophilic phase. At day 5th and day 10th, the temperatures of biocompost with biochar were continuously increased rapidly to 56.02 and 56.42°C, respectively. According to Zhang and Sun (2014), the temperature increased to the thermophilic range for effective composting of 50-60°C. The thermophilic phase which is decomposition of biocompost becomes more active. The temperature of biocompost without biochar from day 5th till day 20th was very slow to increase from 45.25-48.23°C and consume more time to achieve thermophilic phase. The thermophilic stage is one of the most important phases in composting and the high temperatures allow microbes to break down proteins, fats and complex carbohydrates like cellulose and hemicellulose, the major structural molecules in plants. This phase is also important because the high temperatures in the compost pile kill weed seeds and pathogenic organisms. After day 10th, the temperature of biocompost with biochar was gradually decreased to 49.55°C at day 15th and 44.70°C at day 20th due to the cooling process. This stage is the final phase of maturation (curing) of the remaining organic matter. Here, the significant effect of biochars in biocompost is increasing the temperature to reach thermophilic phase and accelerating the time required for decomposition of the feedstock.

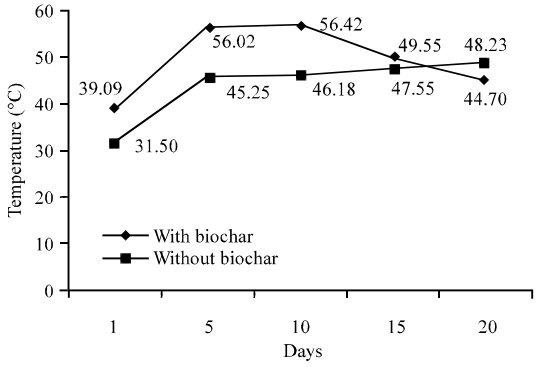

Fig. 1: Biocompost temperature with and without biochar

C/N ratio of biocompost: Figure 2 shows the C/N ratio of bio-compost with biochar. On average, the C/N ratio of biocompost without biochar is approximately, 13.08 and this ratio is considered very low for composting. Low C/N ratio implies the release of several undesirable compounds such as odours or salts which are unfavourable for plant growth (Onwosi *et al*., 2017).

The C/N ratio is important for several aspects of composting but is particularly crucial for the development of microorganisms during composting because it provides the carbon and nitrogen source required for growth.

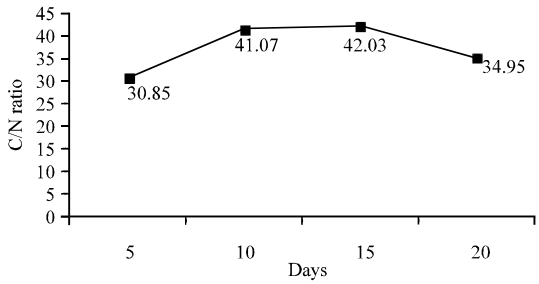

Fig. 2: Biocompost C/N ratio with biochar

Table 1: The ultimate analysis of biocompost with the addition of biochar

	Days			
Elements (%)	5th	10th	15th	20th
Nitrogen (N)	1.26	1.28	1.02	1.16
Carbon (C)	38.86	55.01	42.98	40.65
Hydrogen (H)	7.29	5.67	6.44	6.77
Sulfur (S)	0.31	0.30	0.23	0.36
Oxygen (O)	52.28	37.74	49.33	51.06

Based on Fig. 2 was revealed that addition of biochar into feedstock (kitchen waste) increases the value of C/N ratio which is suitable for composting process which from day 5th till day 20th the C/N ratio in the range 30.85-42.07. According to Maulini-Duran *et al.* (2014) and Yuan *et al.* (2015), the C/N ratio between 20-40 will produce a good result for composting.

Ultimate analysis of biocompost: On average, the ultimate analysis of bio-compost of kitchen waste without the addition of biochar was nitrogen (3.20%), carbon (48.62%), hydrogen (8.34%), sulfur (0.46%) and oxygen (39.38%), respectively.

Table 1 shows the ultimate analysis of biocompost with the addition of biochar with variation day. The percentage of oxygen of biocompost with the addition of biochar is higher compare than without Biochar in the range of 37.78-52.28%. In the composting process, biochar is used as a bulking agent and plays a vital role in providing the aerobic conditions to compost materials. The efficiency of the composting process is strongly affected by O_2 level because the composting process is directly associated with microbial population dynamics (Nakasaki and Hirai, 2017). In term of percentage of Carbon (C) for biocompost with biochar, after day 10th the value percentage gradually decreased from 55.01-40.65% due to the decomposition process. This carbon reduction is an important indicator of compost maturity (Bernai *et al.*, 1998).

CONCLUSION

As a conclusion, this study revealed that temperature continuously increases and achieved the maximum temperature approximately 56.00°C at day 5th and required less time to reach thermophilic phase for active decomposition. Addition of biochar also increased the C/N ratio of kitchen waste with the range 30.85-42.03 which is most suitable for growth organism for biocompost. Oxygen range in between 37.78-52.28% is sufficient for aerobic process.

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